Comparative Analysis of Chest Deflection-Rib Strain Correlation in Occupant Lateral Loading vs. Pedestrian Collision Scenarios

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I. INTRODUCTION

Global road traffic accidents caused 1.19 million deaths in 2021, with pedestrians accounting for 23% (WHO, 2023). In China, pedestrians made up 28.3% of 61,703 traffic fatalities (TMBMPS, 2021), and thoracic injuries are the second most fatal type for pedestrians. Thorax deflection and rib strain are key assessment indicators, but occupant-based protocols have not been validated for pedestrians due to distinct load transmission. This study explores the adaptability of existing occupant thoracic injury assessment methods to pedestrian collisions using the THUMS model,based on typical lateral impact conditions for both occupants and pedestrians, by comparing rib deflection and strain trends under identical simplified lateral loading.

II. METHODS

Model Setup

Pedestrian lateral collision scenarios : a parameterised simplified vehicle model with a mass of 1433 kg, adjustable bonnet leading edge height and bonnet angle, collided with the THUMS v4.02 50th percentile pedestrian model in SAE J2782 posture at impact speeds ranging from 30 to 60 km/h (test conditions detailed in Table 1).

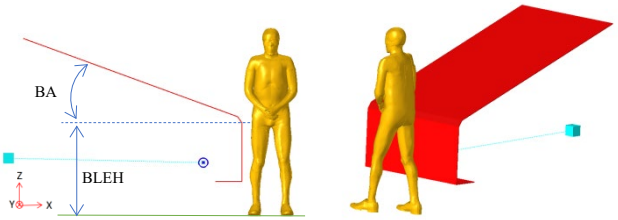

Fig 1. Vehicle-Pedestrian impact model

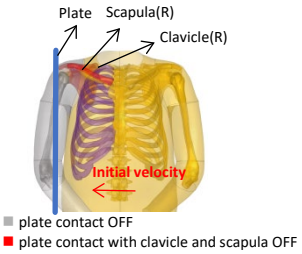

Fig 2. Plate-Occupant impact mode

TABLE 1. SIMULATION MATRIX SETTINGS

Parameter	Level
Vehicle velocity/(km/h)	30, 40, 50, 60
BLEH/(mm)	650, 800, 950, 1100, 1250
BA/(°)	10, 15, 20

Occupant lateral collision scenarios：the THUMS model was impacted against a fixed rigid plate with contact restricted to the thorax; the impact velocity ranged from 5 to 60 km/h and the test was configured with eight total cases.

Output Settings

With identical measurement approaches used for the two models, the maximum lateral deflection of ribs 1–10 relative to the thoracic vertebrae and the 95th percentile maximum principal strain of rib cortical bone were recorded.Linear regression was performed for each rib to evaluate the correlation between deflection and strain, with the coefficient of determination (R^2) reported.

III. INITIAL FINDINGS

Rib Strain-Deflection Correlation

Occupant model: All ribs showed high correlations (R^2>0.8) between strain and deflection.

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Pedestrian scenarios: ribs 4–7 had moderate correlations (R^2>0.6), ribs 1–3 and 9–10 had poor correlations (R^2<0.5), ribs 3–6 showed relatively similar strain-deflection relationships across scenarios, and ribs 1, 2, 7–10 exhibited significant deviations.

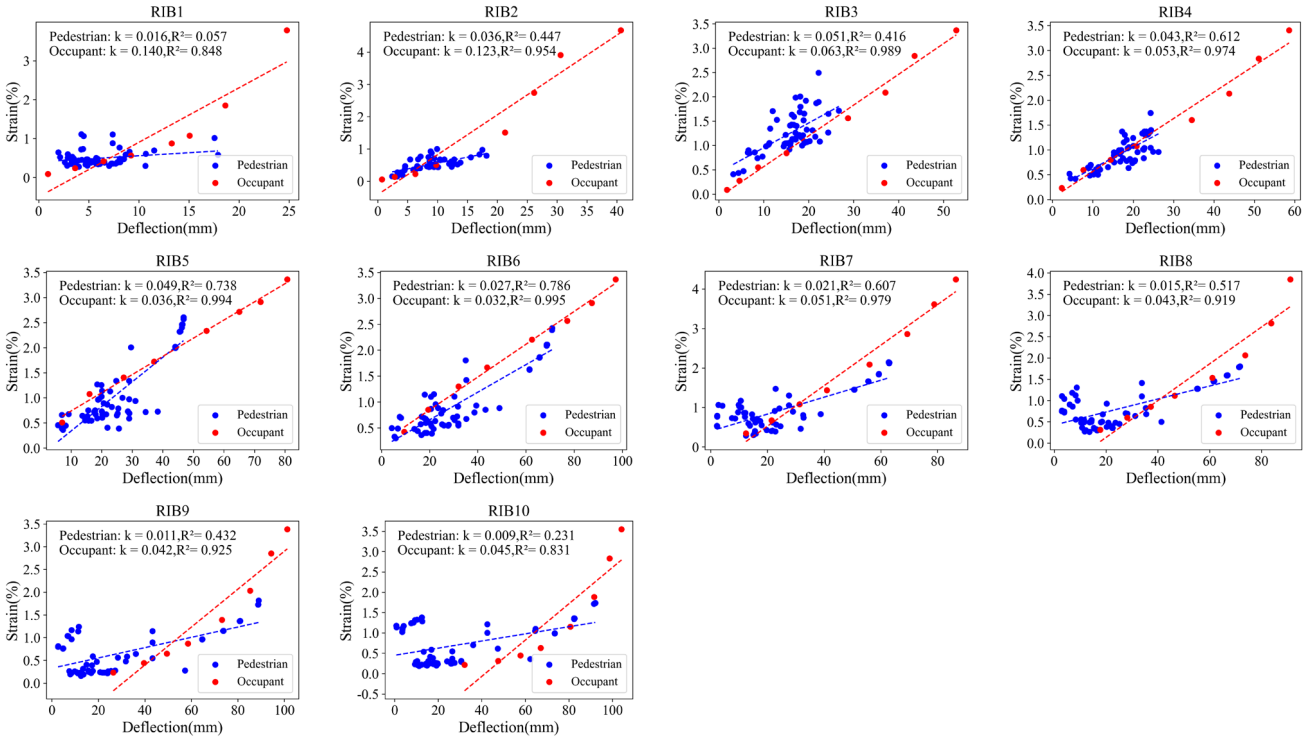

Fig 3. Comparative fitted strain-deflection correlation trend lines

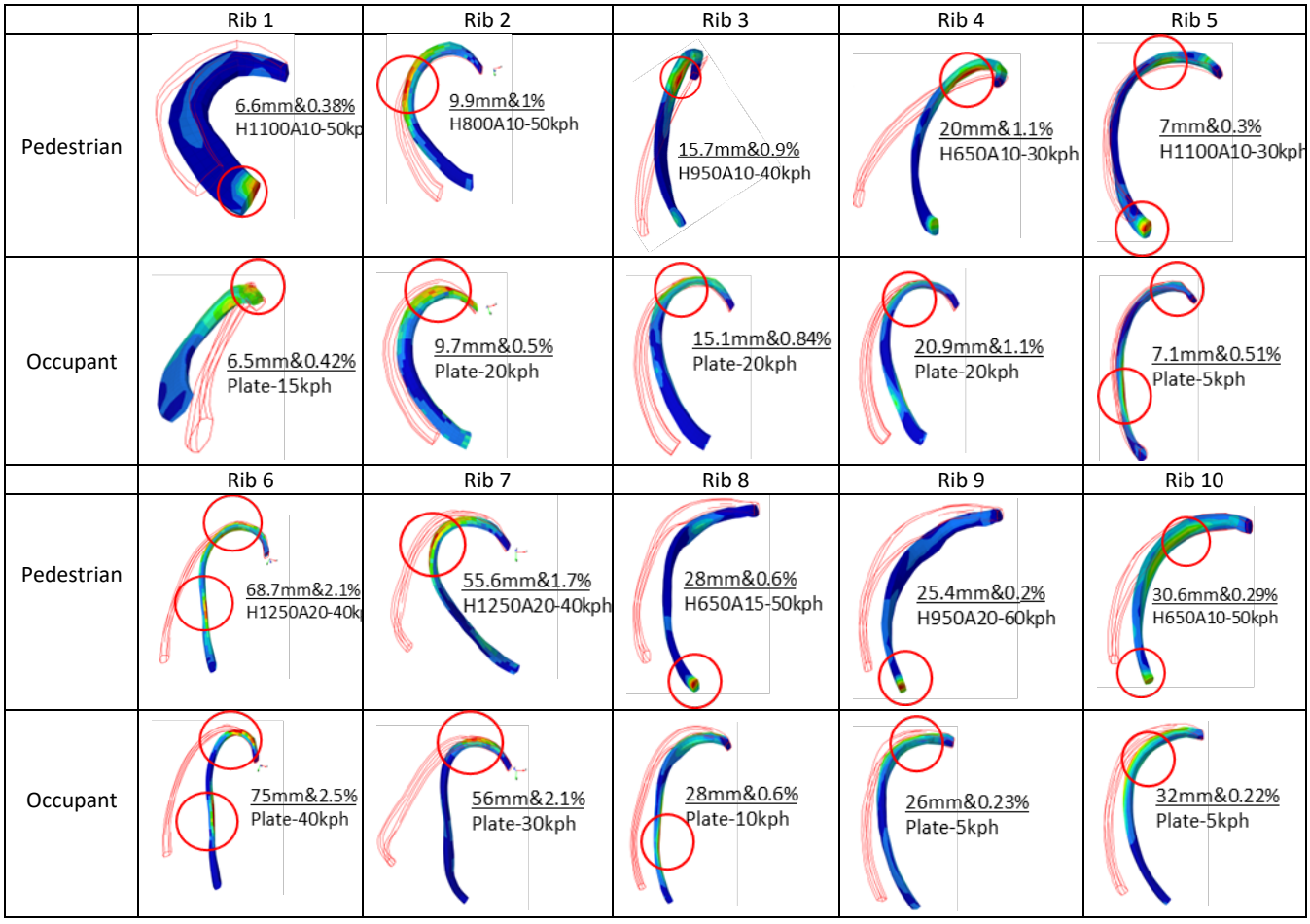

Fig 4.Strain contour plots for ribs 1-10 at time of peak strain occurrence

Maximum Strain Location

At similar rib deflections in pedestrian and occupant scenarios, ribs 1–2 and 7–10 exhibit significant differences in maximum strain locations, while ribs 3–6 show relatively close positions.

IV. DISCUSSION

Pedestrians' upper/lower ribs experience complex stresses from shoulder, abdominal, and muscle forces, leading to poor strain-deflection correlations. Occupants' ribs are less affected by such traction, resulting in strong correlations. Same deflection values correspond to different strains for ribs 8-10, invalidating direct application of occupant IRFs to pedestrians. Limitations include reliance on a single HBM and standing posture simulation, and future work will validate with multiple models.

V. REFERENCES

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